INSTRUCTION MANUAL *for...*

MODEL VCO-718
VOLTAGE - CONTROLLED OSCILLATOR

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CALIBRATION LAB.
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275 MASSACHUSETTS AVENUE • CAMBRIDGE 39, MASSACHUSETTS

MODEL VCO-718
VOLTAGE - CONTROLLED OSCILLATOR

Model No. _____

Serial No. _____

TABLE OF CONTENTS

PART I

GENERAL INFORMATION		Page No.
I.	Purpose of the Handbook	I-1
II.	Purpose of the Equipment	I-1
III.	Principles of Operation	I-1
	A. Typical Operation	I-1
	Figure I-1, VCO-718, Block Diagram Showing Typical Application	I-2
	B. Static Mode of Operation	I-3
	C. Dynamic Mode of Operation	I-3
IV.	Specifications and Characteristics	I-4

PART II

INSTALLATION		
I.	General	II-1
II.	Inspecting and Unpacking the Shipping Crate	II-1
III.	Inspecting the Uncrated Unit	II-1
IV.	General Construction and Installation	II-2
V.	Initial Operating	II-2
VI.	Power Requirement	II-2
VII.	Temperature Range	II-2

PART III

OPERATION		
I.	General Characteristics	III-1
II.	Setting the Oscillating Frequency	III-1
III.	Deviating the Oscillating Frequency	III-2
IV.	Calibrating a Typical Discriminator	III-3

TABLE OF CONTENTS (Continued)

PART III (Continued)

Figure III-1 Block Diagram Showing Discriminator Test Set-up III-5

Figure III-2 Laboratory Method of Adjusting Wow-and-Flutter Compensation System III-5

Table III-1 Standard Subcarrier Frequencies III-6

PART IV

THEORY OF OPERATION

I. General Theory IV-1

II. Detailed Theory IV-1

A. Free-Running Multivibrator IV-1

Figure IV-1 VCO-718 Simplified Block Diagram IV-2

B. Regulated Power Supply IV-3

C. Deviation Circuitry IV-4

D. Output Stage IV-5

PART V

MAINTENANCE

I. General V-1

II. Periodic Inspection and Preventive Maintenance V-1

A. Preventive Maintenance V-1

B. Operation and Calibration Test Procedure V-2

C. Output Symmetry Adjustment V-5

TABLE OF CONTENTS (Continued)

PART V (Continued)

III.	Corrective Maintenance	V-7
	A. General	V-7
	B. Trouble-Shooting Procedure	V-8
	Table V-1 System Trouble Shooting	V-9

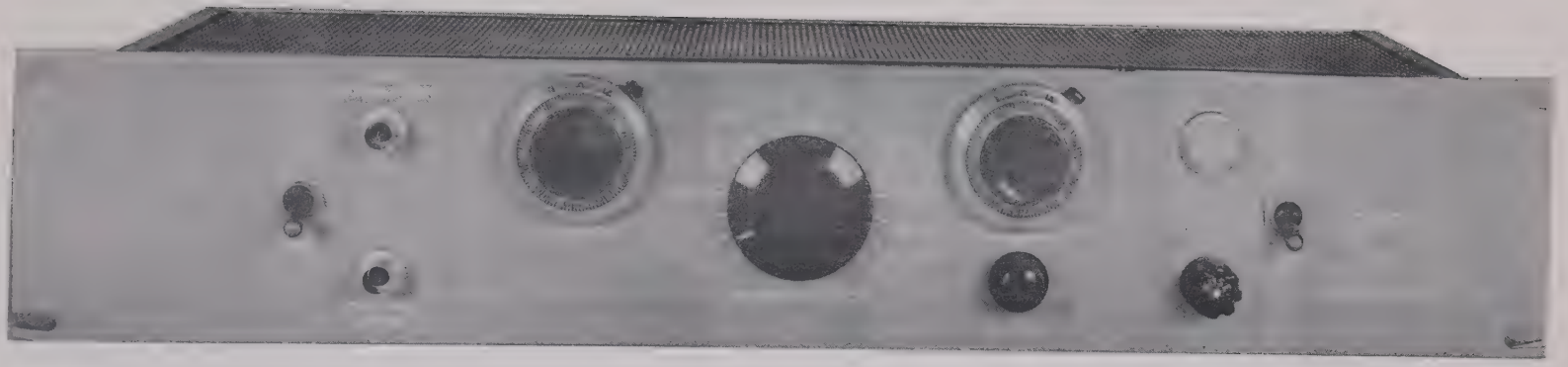
PART VI

	Components List	VI-1

PART VII

DRAWINGS

	Figure VII-1 VCO-718 Schematic	VII-1



EPSCO MODEL VCO-718 VOLTAGE-CONTROLLED OSCILLATOR

PART I

GENERAL DESCRIPTION

1. PURPOSE OF THE HANDBOOK

The purpose of this handbook is to describe operation and maintenance procedures for the EPSCO Model VCO-718 Voltage-Controlled Test Oscillator.

II. PURPOSE OF THE EQUIPMENT

The VCO-718 (Figure I-1) is a precision test oscillator designed to generate a signal at any point on any one of the twenty-three MIL-T-26985 (IRIG) telemetering channels and also on the reference-frequency band.* This especially adapts the unit to check and align equipment used in telemetry receiving and data-reduction stations. By applying an external modulation signal to the VCO-718, its output signal can be frequency modulated. The amount that the FM output signal is deviated each side of a predetermined center frequency can be very accurately set. This permits the FM output signal of the VCO-718, which accurately simulates a modulated subcarrier signal, to be used in testing and servicing telemetry equipment and telemetry systems. (See Figure I-2)

III. PRINCIPLES OF OPERATION

A. TYPICAL OPERATION

The VCO-718 is a multivibrator-type oscillator that produces an inherently-accurate, dynamically-stable output signal at any point of any one of the 23 IRIG telemetry bands. It also functions on any one of the reference frequencies associated with magnetic-tape compensation systems. Adequate circuitry is provided so that the output frequency can be easily set to any one of these desired frequencies. Additional circuitry is provided so that the output frequency can be instantaneously deviated by applying an external stimulus voltage. If the applied stimulus voltage is of a constant potential

* See Table III-1

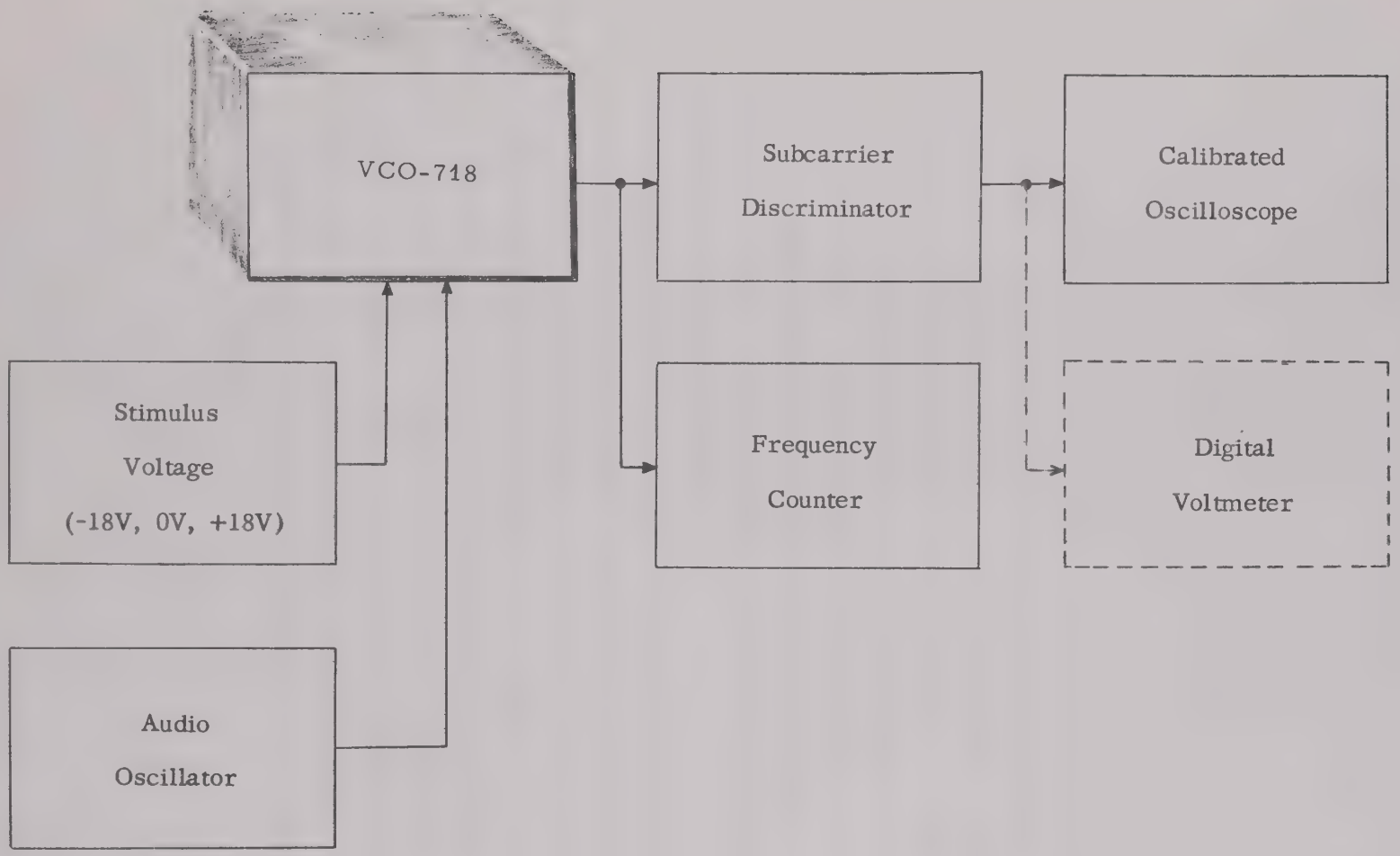


Figure I-1- VCO-718 Block Diagram Showing Typical Application

then the output signal of the VCO-718 will be of a constant frequency. This is known as the Static Mode of Operation. However, if the applied stimulus voltage is of a varying potential then the output signal of the VCO-718 will be frequency modulated in accordance with the varying potential of the stimulus signal. This is known as the Dynamic Mode of Operation.

B. STATIC MODE OF OPERATION

By adjusting the CHANNEL SELECTOR, CENTER FREQ., and VERNER controls, the VCO-718 can be made to oscillate at any point on any one of the 23 IRIG bands. However, additional frequencies can be obtained by applying a d-c potential through the INPUT MODULATION connector and adjusting the DEVIATION control for the desired output frequency. If the applied d-c potential is of a very low value (i.e., 1.5 volts) then the DEVIATION control can be used as a vernier on the VERNIER control for setting the VCO-718 to a very exacting output frequency. If the applied deviation voltage is of a high potential (i.e. greater than 15 volts) then the output frequency can be deviated to frequencies greatly in excess of those obtainable with the CENTER FREQ. control for any setting of the CHANNEL SELECTOR switch.

C. DYNAMIC MODE OF OPERATION

When the VCO-718 is modulated by an external a-c signal (usually sinusoidal such as that from a standard laboratory audio oscillator) then the output signal of the VCO-718 is frequency modulated. The resulting square-wave output signal simulates not only a subcarrier signal but also simulates an information signal being received on that channel as well. In this mode of operation the VCO-718 can check the overall dynamic operation of a subcarrier discriminator such as a Epsco FM-108A or FM-102. Thus, by rotating the CHANNEL SELECTOR switch, with the VCO-718 in this mode of operation, the dynamic performance of a complete telemetry receiving station can be speedily checked-out channel by channel.

IV. SPECIFICATIONS AND CHARACTERISTICS

OUTPUTS	Two symmetrical squarewave outputs of 5 and 50 volts (minimum) peak-to-peak are provided.
OUTPUT IMPEDANCE	a. Approximately 200 ohms for the 50 volt output. b. Approximately two kilohms for the 5.0 volt output.
CHANNEL SELECTION	Switching to any one of the 23 MIL-T-26985 (IRIG) channels is accomplished by means of a single rotary selector switch.
LINEARITY	Non-linear deviations from a mean straight line over the entire frequency deviation range will not exceed 0.1% for subcarrier bands 1-18 (±7.5%) and 0.2% for subcarrier bands A-E (±15%).
INPUT INTELLIGENCE FREQUENCY RESPONSE	Uniform within ±2% of bandwidth for sine wave modulation frequencies up to 50% of channel bandwidth.
MODULATION INFORMATION INPUT IMPEDANCE	50 kilohms, (Minimum)
DEVIATION SENSITIVITY	1/2% deviation per volt and 1% deviation per volt for ±7.5% and ±15% deviation settings; respectively. A precision sensitivity control is provided.
WARM-UP TIME FOR OPERATIONAL STABILITY	30 minutes.

POWER REQUIREMENTS	105 to 125 volts ac; 55 cps to 65 cps; approximately 40 watts.
TEMPERATURE RANGE	The equipment is designed for an ambient temperature range of -25°C to + 45°C when provided with normal cooling air flow.
HUMIDITY	The test oscillator will operate satisfactorily when subjected to a relative humidity of 95% at 35°C.
SIZE	Standard 19 inch panel x 3-1/2 inches high x 10 inches deep.
WEIGHT	15 pounds.
FINISH	Epsco Gray
FREQUENCY RANGE	The frequency limits of each band overlaps so that any frequency in the telemetering spectra is available.

PART II
INSTALLATION

I. GENERAL

The VCO-718 is given a thorough operational test at the factory before being securely packed in its shipping container. Therefore, if the following unpacking and inspecting instructions are followed, it should be possible to place the unit into immediate service.

II. INSPECTING AND UNPACKING THE SHIPPING CRATE

Before the VCO-718 is unpacked, the shipping crate should be inspected for external signs of shipping damage. If any damage is noted, reports should be made immediately to all interested parties. If there are no signs of shipping damage proceed as follows:

a. Place crate on a work bench with TOP up.

b. Open packing crate and remove packing material surrounding the VCO-718.

CAUTION

Do not use pry bars or knives in removing the crate since tools of this nature may extend into the package and damage the unit.

c. Remove the VCO-718 from the crate.

d. Remove all packing material and shipping tape attached to the VCO-718

III. INSPECTING THE UNCRATED UNIT

After the VCO-718 is uncrated it should be immediately inspected for signs of shipping damage. Also the VCO-718 should be checked against the

packing list to make certain that all the component assemblies listed therein have been supplied. If any damage or shortage is noted, reports should be made immediately to all interested parties.

IV. GENERAL CONSTRUCTION AND INSTALLATION

The VCO-718 is constructed of rugged light-weight aluminum that is decoratively finished in Epsco Gray. The unit, designed to be mounted in a standard equipment cabinet, is contained behind a standard 3-1/2 inch high by 19 inch wide rack panel. It extends 10 inches behind the front panel. Since the component parts are protected by a metal screen, the VCO-718 can be used either as a unit in an equipment cabinet or as a test oscillator setting on a laboratory test bench.

V. INITIAL OPERATION

To place the VCO-718 into service; it is only necessary to connect the input power cord to a 115 volt 60 cycle power line, attach a cable to one of the OUTPUT connectors, and place the power switch in its ON position.

VI. POWER REQUIREMENT

For optimum operational stability the power supplied to the VCO-718 should be 105 to 125 volts a-c; 55 to 65 cps; approximately 40 watts. One percent a-c line regulation is recommended.

VII. TEMPERATURE RANGE

The VCO-718 has been designed to operate in an ambient temperature ranging from -13°F (-25°C) to +113°F (+45°C).

PART III

OPERATION

I. GENERAL CHARACTERISTICS

The VCO-718 is essentially a multivibrator-type oscillator. However, it incorporates many circuit refinements that combine to produce an inherently-accurate, dynamically-stable output signal whose frequency can be internally set to any value from below 370 cycles to above 100 kc. This is accomplished by adjusting the CHANNEL SELECTOR, CENTER FREQ., and VERNIER controls. Additional circuitry is incorporated so that the output signal can be deviated and/or frequency modulated by applying an external stimulus voltage to the INPUT MODULATION connector. The amount of deviation and/or frequency modulation can be accurately set with the DEVIATION control and the 7.5%/15% deviation range switch.

II. SETTING THE OSCILLATING FREQUENCY

The frequency at which the multivibrator circuit oscillates is determined by the position of the CHANNEL SELECTOR switch and by the setting of the CENTER FREQ. and VERNIER controls. (The oscillating frequency is also determined by the setting of the DEVIATION control when an external modulating signal is applied but this is discussed in paragraph IV.) As discussed in the Theory of Operation section, the CHANNEL SELECTOR switch selects the value of capacitance that sets the basic frequency of oscillation of the multivibrator circuit. The CENTER FREQ. and VERNIER controls are variable resistors, in series with the controlled current source, that form part of the resistance in the discharge circuit of the precision capacitors. By varying the CENTER FREQ. control from its 0.00 setting to its 10.00 setting, the output frequency can be varied from the lower band-edge to the upper band-edge frequency on each channel. On most channels it will be noted that center frequency will be obtained at

approximately the 6.00 setting of the CENTER FREQ. control. The VERNIER control, normally set to its mid-range position, provides a means of adjusting the oscillator to an exact frequency with much greater ease and accuracy than can sometimes be obtained with the CENTER FREQ. control.

III. DEVIATING THE OSCILLATING FREQUENCY

Once the oscillating frequency of the multivibrator circuit has been set, as described in paragraph 3-2, then a modulating signal can be applied through the INPUT MODULATION connector. This modulating signal can have a d-c, an a-c, or a pulsating d-c potential. The modulating signal will alter the frequency of the multivibrator in accordance with the type and amplitude of the applied signal and with the setting of the DEVIATION control and the 7.5%/15% toggle switch.

a. STATIC MODE OF OPERATION

A d-c potential will deviate the frequency of the multivibrator much the same as the CENTER FREQ. control does. However, because of the wide range of external voltage that may be applied, the output frequency of the multivibrator can be deviated over a much greater range than is possible with the CENTER FREQ. control. Furthermore, by applying a very low-voltage d-c signal, the DEVIATION control can be used as a vernier on the VERNIER control when exacting frequencies are required. When thus using an external d-c modulating signal, the VCO-718 is said to be used in its Static Mode of Operation.

The Static Mode of Operation is used when a steady, constant-frequency output signal is desired. This is required when aligning or checking the center frequency and/or across-the-band response characteristics of a subcarrier discriminator. It is also used when checking and/or

plotting the response characteristics of IRIG band-pass filters.

b. DYNAMIC MODE OF OPERATION

When an a-c or a pulsating d-c signal is applied to the INPUT MODULATION connector then the output signal of the VCO-718 will be frequency modulated in accordance with the amplitude and frequency of the a-c component of the applied signal. The d-c component of pulsating d-c signals will shift the center frequency about which the output signal will be deviated. The bandwidth of the frequency-modulated output signal is determined by the amplitude of the applied a-c signal and the setting of the DEVIATION control; the rate at which the output signal is swept across its spectrum is determined by the frequency of the applied a-c signal. When using an external a-c or pulsating d-c signal to modulate the VCO-718, it is said to be used in its Dynamic Mode of Operation.

The Dynamic Mode of Operation is used whenever a simulated frequency-modulated subcarrier signal is required, as is the case when checking the synamic operation of a subcarrier discriminator. With the VCO-718 in this mode of operation, the dynamic performance of a complete telemetry receiving station can be speedily checked-out channel by channel.

IV. CALIBRATING A TYPICAL DISCRIMINATOR

The following procedure describes the general steps necessary to balance a typical subcarrier discriminator using a VCO-718. For any specific installation, operating personnel should integrate this procedure with the instructions given in the instruction manual supplied with their subcarrier discriminator.

a. Interconnect the VCO-718 and the subcarrier discriminator to be balanced with a stimulus voltage source, a frequency counter, and a digital voltmeter as shown in Figure III-1

b. Apply power and allow all the units to warm-up for a period of at least 30 minutes.

c. Attach the INPUT MODULATION cable to the 0V connector on the stimulus voltage box.

d. Adjust the CHANNEL SELECTOR, CENTER FREQ., and VERNIER controls on the VCO-718 as necessary to produce the center frequency, of the channel to be set-up. This will be displayed on the frequency counter. (Refer to Table III-1)

NOTE

The VCO-718 can be set to 100 kc by placing the CHANNEL SELECTOR control to any of the unnumbered positions between the 70 kc and the .40 kc positions.

e. Adjust the "balance" control on the subcarrier discriminator so as to produce the center frequency output voltage (usually zero volts) on the digital voltmeter.

f. Remove the INPUT MODULATION cable from the 0V connector and attach it to the +18V connector on the stimulus voltage box.

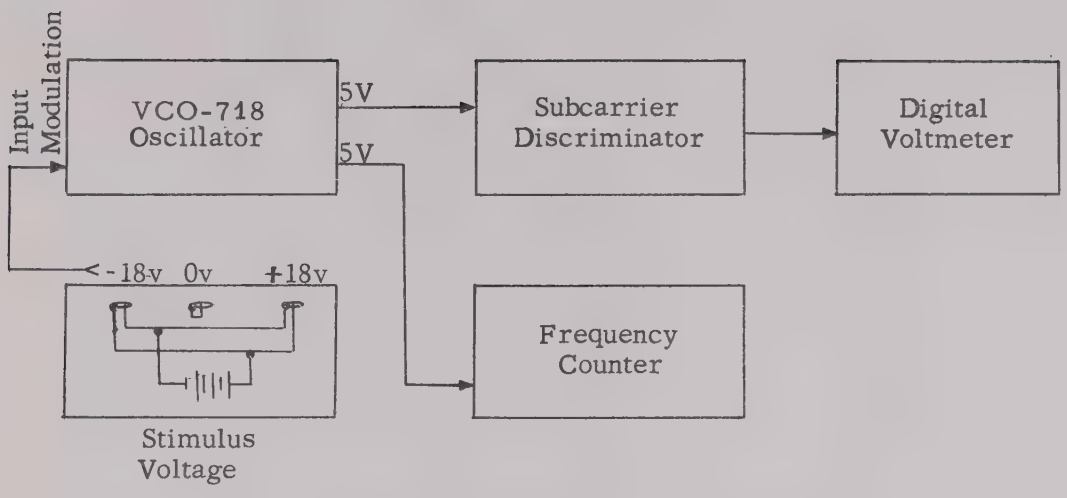


Figure III-1 Block Diagram Showing Discriminator Test Set-Up

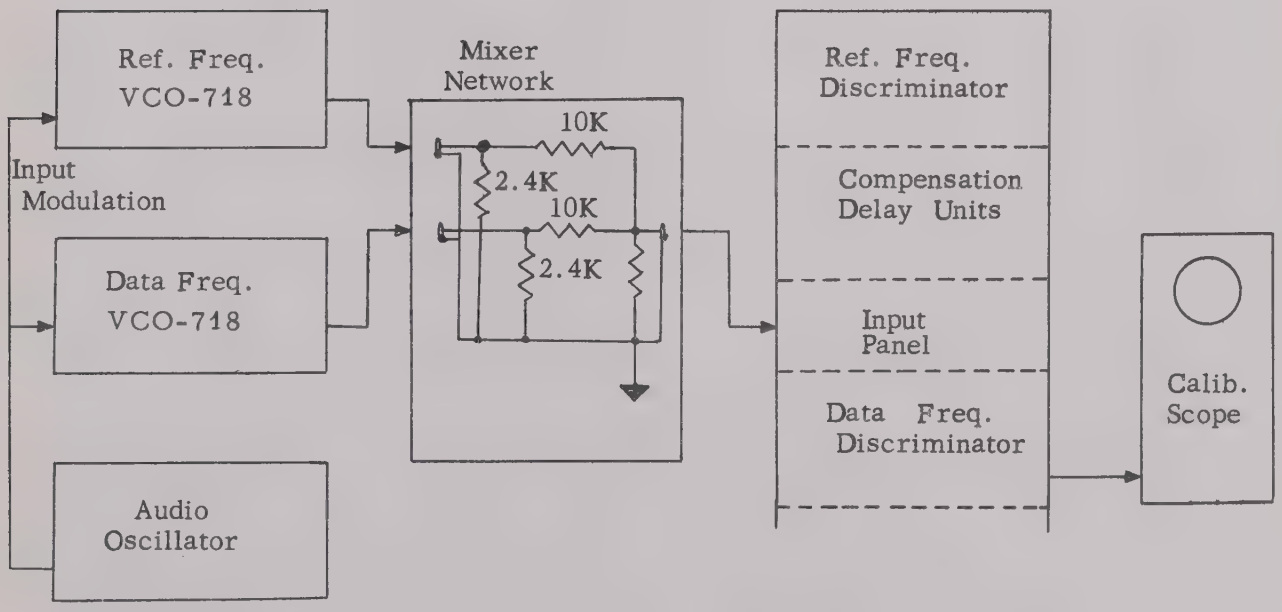


Figure III-2 Laboratory Method of Adjusting Wow-And-Flutter Compensation System

TABLE III-1

STANDARD SUBCARRIER FREQUENCIES

IRIG BAND	LOWER LIMIT (cps)	CENTER FREQ. (cps)	UPPER LIMIT (cps)	BANDWIDTH DEVIATION (per cent)	FREQ. RESPONSE (cps)
1	370	400	430	±7.5%	6
2	518	560	602	±7.5%	8
3	675	730	785	±7.5%	II
4	888	960	1032	±7.5%	14
5	1202	1300	1398	±7.5%	20
6	1572	1700	1828	±7.5%	25
7	2127	2300	2473	±7.5%	35
8	2775	3000	3225	±7.5%	45
9	3607	3900	4193	±7.5%	60
10	4995	5400	5805	±7.5%	80
II	6799	7350	7901	±7.5%	II0
12	9712	10,500	II,288	±7.5%	160
13	13,412	14,500	15,588	±7.5%	220
14	20,350	22,000	23,650	±7.5%	330
15	27,750	30,000	32,250	±7.5%	450
16	37,000	40,000	43,000	±7.5%	600
17	48,560	52,500	56,440	±7.5%	790
18	64,750	70,000	72,250	±7.5%	1,050
OPTION BANDS:					
* A	18,700	22,000	25,300	±15%	660
* B	25,500	30,000	34,500	±15%	900
* C	34,000	40,000	46,000	±15%	1,200
* D	44,620	52,500	60,380	±15%	1,600
* E	59,500	70,000	80,500	±15%	2,100
REFERENCE FREQUENCY BANDS:					
*	15,725	17,000	18,275	±7.5%	
*	23,125	25,000	26,875	±7.5%	
*	46,250	50,000	53,750	±7.5%	
*	42,500	50,000	57,500	±15%	
-	85,250	93,000	100,750	±8.3%	
-	92,500	1,00.000	107,500	±7.5%	

* NOTE: To use these bands some other bands must be omitted

g. Adjust the DEVIATION control on the VCO-718 until the output frequency corresponds to the upper-band-edge limit. (Refer to Table III-1.)

h. Adjust the "gain" control on the discriminator until the upper-band-edge output voltage is displayed on the digital voltmeter.

i. Remove the INPUT MODULATION cable from the +18V connector on the stimulus voltage box and attach it to the -18V connector.

j. The frequency counter should now indicate the lower-band-edge frequency and the digital voltmeter should indicate the lower-band-edge voltage.

k. Repeat the above steps for each discriminator to be calibrated.

l. Remove the interconnecting cables and reinstall any cables that may have been removed in step a. above.

m. Shut-off the input power to the test equipment.

n. The discriminator(s) are now balanced and ready for use.

V. ADJUSTING THE DELAY UNITS IN A WOW-AND-FLUTTER COMPENSATION SYSTEM

The compensation delay units used in a magnetic-tape compensation system can be quickly and accurately adjusted by using two VCO-718 oscillators along with a few other standard, laboratory test instruments. These units should be interconnected as shown in Figure III-2. This procedure is permissible only because a given input voltage will deviate the output frequency of both VCO-718 oscillators the same proportionate amount. Therefore, it is essential that the center frequency and band edge frequency adjustments be set exactly and that the CENTER FREQ. and DEVIATION controls be securely locked once these settings have been made. It is also essential that the INPUT MODULATION signal be kept to a peak-to-peak amplitude of 15 volts or less.

a. Set the "balance" and "gain" of both the REF. FREQ. and the DATA FREQ. discriminators as outlined in paragraph IV-4.

NOTE

Lock the CENTER FREQ. and the DEVIATION controls on each VCO-718 at the center frequency and full bandwidth settings, respectively.

b. Interconnect the units as shown in Figure III-2

c. Apply power to all units and allow sufficient time for each to warm-up and stabilize.

d. Adjust the output frequency of the audio oscillator to that of the most prevalent wow-and-flutter frequency to be encountered.

NOTE

Wow-and-flutter frequency is usually of a random nature; therefore, if the "most prevalent frequency" is not known set the audio oscillator to the IRIG low-pass-filter cutoff frequency. (See Table III-1)

e. Set the output amplitude control of the audio oscillator to its mid range position.

f. Remove the wow-and-flutter compensation signal from the DATA FREQ. discriminator.

g. Adjust the controls on the oscilloscope so that a two cycle waveform is displayed on its screen.

h. Set the amplitude control on the audio oscillator just below the point where the displayed signal becomes distorted. (The peak-to-peak value of the audio oscillator signal should not exceed 15 volts.)

i. Reapply the wow-and-flutter compensation signal to the DATA FREQ. discriminator.

j. Adjust first the "delay" control and then the "level" control on the compensation unit associated with the DATA FREQ. discriminator for a minimum signal on the oscilloscope. (Recheck for interaction of controls.)

k. Calibrate the oscilloscope trace for a full screen deflection of 10 volts.

l. Remove the wow-and-flutter compensation signal from the DATA FREQ. discriminator.

m. Adjust the amplitude control on the audio oscillator so that the two-cycle waveform on the oscilloscope screen has a peak-to-peak amplitude of 10 volts.

n. Reapply the wow-and flutter compensation signal to the DATA FREQ. discriminator.

o. Record the peak-to-peak amplitude of the compensated signal (noise) as displayed on the oscilloscope screen.

p. Calculate the db improvement factor by using the following formula:

$$\text{db impr.} = 20 \log \frac{E \text{ off}}{E \text{ on}}$$

where:

E off = 10 (per step m.)

E on = value recorded in step o.

q. Repeat the above procedure for each compensation delay network to be adjusted.

r. Remove the interconnecting cables of the test instruments and reattach any cables that may have been removed in steps a. or b. above.

s. Shut-off the input power to the test instruments.

t. The magnetic-tape compensation system is now adjusted and ready for use.

PART IV

THEORY OF OPERATION

I. GENERAL THEORY

The VCO-718 consists of a self-contained regulated d-c power supply, and a regulated adjustable current source feeding a high-speed multivibrator, the switching current of which alternately discharges to ground through two banks of precision capacitors. (See Figure IV-1) The time constants thus formed produce the various repetition rates of the multivibrator which represents the frequencies of the IRIG channels. The output of the high-speed multivibrator is cathode-follower coupled and is taken out at two different voltage levels, 5 volts and 50 volts, for convenience of application.

The novel elements of the circuitry are the direct coupled free-running multivibrators, and its associated cathode-follower plate-to-grid coupling elements; the controlled current source, and the method of clamping the multivibrator to a +150 volt level, so that, when one half of the multivibrator is cut off its associated capacitor is allowed to descharge through the current source to ground. (See Figure VII-1)

II DETAILED THEORY

A. FREE-RUNNING MULTIVIBRATOR

The free-running multivibrator circuitry consists of cathode follower V1B whose grid is biased so as to provide a constant +150 volt d-c level at its cathode. This 150 volt potential is applied to diode clamps V4A and B to clamp the cathode of the high-speed multivibrator at this level. Tube V3 is the high-speed multivibrator, one half of which is normally conducting. At any given time, the half of V3 that is conducting has its cathode clamped by V4A or B. These cathodes are connected, as described, directly to the current sources and are returned to ground through the banks of precision

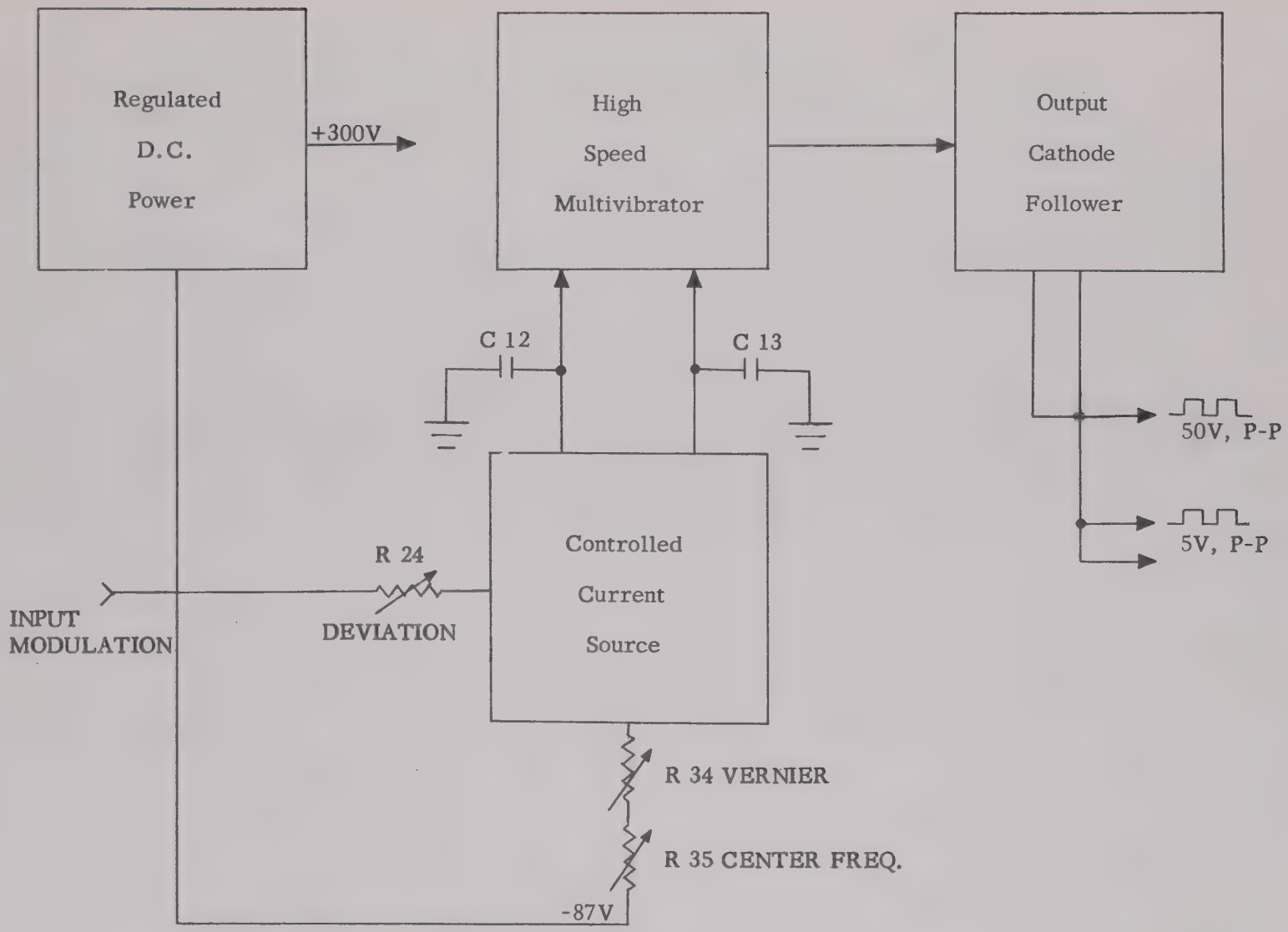


Figure 4-1 VCO-718 Simplified Block Diagram

capacitors, C12a through C12t, and C13a through C13t, respectively, Variable capacitors C25 and C25 are factory adjustments for setting the square-wave symmetry of the output signal.

The action of front panel switch S3, the CHANNEL SELECTOR Switch, is to switch in the proper pairs of precision capacitors necessary to produce the switching action of the multivibrator at the frequency of the channel selected. Assuming that V3A is conducting, the selected element of C12 will be charged to the 150 volt level to which the cathode of V3A is clamped by V4A. V3B, which is cut off, will have its grid biased at approximately 110 volts. The element of C13 in use will be discharged from its original +150 d-c level. When C13 discharges to a voltage level such that the grid voltage rises above cut off, V3B will conduct. The switching signal at the plate of V3B is coupled into the grid of V3A through a cathode follower, V2A, whose purpose is to provide fast switching action for the multivibrator stage. With V3B conducting, its cathode rises toward +150 volts and capacitor C13 is recharged by the current flowing in V3B. V3A is now cut off, and capacitor C12 begins to discharge, and the cycle repeats. The current which is discharged from precision capacitors C12 and C13 by the switching action, is derived from the current flowing in V3.

B. REGULATED POWER SUPPLY

The regulated power supply consists of tubes V6, V7, V9, and V10 together with their associated circuit components. Tube V7 is a differential amplifier that closes the loop of the power supply and controls the series regulator tube V8. It will be noted that gas regulator tubes V6 and V10 are the reference and pre-reference tubes (respectively) from which the stable -87 volt and +300 volt potentials are derived. The -87 volt potential is perhaps the most critical voltage in the entire circuit. It supplies the reference potential for the current sources which, in turn, directly controls

the deviation linearity and output frequency of the multivibrator circuit.

C. DEVIATION CIRCUITRY

The conductance of the controlled current source tube V5, which determines the oscillating frequency of the multivibrator, is varied in two ways. One way is by adjusting either of the two variable resistors, R34, and R35, which act as a cathode voltage divider network to the -87 volt supply. Variable resistor R35 is the CENTER FREQ. control and R34 is the VERNIER control both, of which, are located on the front panel. By means of these two controls, the output frequency of the VCO-718 is established and allowed to remain constant for any setting of the CHANNEL SELECTOR switch. The other way in which the conductance of the current source, and hence the switching action of the multivibrator is changed, is by applying a signal, either d-c or a-c, to the control grids of V5. This applied signal is introduced through the INPUT MODULATION jack and is applied across R24, the DEVIATION control. Consequetly, the position of the center arm of R24 will determine the amount of the modulating signal that is impressed on the gride of V5. Hence, the action of a constant input voltage in the Static Mode of Operation or of an alternating input signal in the Dynamic Mode of Operation, is simply to change the conductance of the controlled current source tube V5 and in this manner affect the oscillating frequency of the multivibrator circuit.

In connection with this portion of the circuit, it should be noted that the front panel deviation range switch, S2, which is placed in the appropriate position for using either 7.5% deviation channels or 15% deviation channels, has the effect of changing the total input impedance. In the case of the ±7.5% deviation channels, switch S2 is in its open position, and the total input impedance seen by the modulation signal is 100 kilohms. With switch S2 in its ±15% position, which is its closed position, resistor R23 is shorted out and

the total input impedance is 50 kilohms. In this case, the DEVIATION control R24 senses more of the voltage drop and thus vary the frequency of the multivibrator a greater amount.

D. OUTPUT STAGE

The output stage consists of cathode follower V1A and its associated circuit components. The square-wave signal of the multivibrator circuit, taken from the cathode of the switching tube V2B, is applied to the grid of V1A. The resistive voltage divider circuit in the cathode circuit of V1A consisting of R30 and R31 provides the 50 volt and 5 volt output potentials available from the VCO-718. It should be noted that the 50-volt output connector, marked HIGH LEVEL on Figure VII-1 and one of the 5-volt output connectors, marked LOW LEVEL on Figure VII-1, are located on the rear panel of the VCO-718. The other 5-volt output connector, marked OUTPUT, is located on the front panel. The 50-volt output signal has a source impedance of approximately 200 ohms; the 5-volt output signals have a source impedance of approximately 2 kilohms.

PART V
MAINTENANCE

I. GENERAL

The information and procedures outlined in this section are to assist maintenance personnel in establishing a preventive maintenance schedule and, also, to assist them in repairing any malfunctioning circuit. This section presupposes that maintenance specialists are thoroughly familiar with the physical make-up, operational characteristics, and circuit theory as described elsewhere in this manual.

II. PERIODIC INSPECTION AND PREVENTIVE MAINTENANCE

Since the VCO-718 is a precision test instrument, the following periodic inspections and preventive maintenance procedures should be performed at least every 60 days to insure the accuracy of the equipment.

A. PREVENTIVE MAINTENANCE

(I) Remove and retain the attaching screws of the upper and lower perforated dust covers and then remove and retain the dust covers.

(2) Remove all accumulated dust from the equipment and the dust covers with either an industrial vacuum cleaner or a stream of dry, compressed air.

(3) Visually inspect all components and wires. Replace those showing signs of deterioration or failure.

(4) Check all vacuum tubes on a dynamic tube tester. Replace those tubes whose mutual conductance is down 30% or more.

NOTE

Each vacuum tube should be reinstalled in the same socket from which it was removed.

(5) Check to see that all set screws and mounting hardware are tight.

(6) Reinstall the dust covers and the attaching hardware retained in step (1) of this paragraph.

B. OPERATION AND CALIBRATION TEST PROCEDURE

The following inspections of the operation and calibration of the VCO-718 should be performed following the preventive maintenance procedures listed in paragraph II-A. This procedure should also be performed following the replacement of any circuit component that fails during operation.

(1) Connect the power cord to a regulated power source that supplies 115 volt 60 cycle a-c power.

(2) Place the ON-OFF switch in its ON position and allow the equipment to warm up for at least 30 minutes.

(3) Set the front panel controls to their following positions:

CHANNEL SELECTOR switch to .40 KC
DEVIATION control to 0 00
7.5%/15% switch to 7.5%
CENTER FREQ. control to 0 00
VERNIER knob to its full ccw position

(4) Connect a frequency meter (Berkeley Model 7150 B or equivalent) to the OUTPUT connector on the front panel of the VCO-718 and an oscilloscope (Dumont 304 A or equivalent) to the lower BNC connector on the rear panel of the VCO-718.

(5) Observe the output waveform and record the output frequency of each channel as the CHANNEL SELECTOR switch is successively placed in each of its 24 positions (frequency counter set for a one-second count.)

NOTE

The output waveform of each channel should be a smooth square wave having equal positive-going and negative-going cycles. If the output waveform, as viewed on the oscilloscope, is either distorted or missing then the trouble-shooting procedure listed in paragraph III should be consulted to locate the cause of the malfunction. The faulty component should be repaired or replaced and then this entire calibration procedure should be repeated. If the output waveform is non-symmetrical refer to paragraph II-C.

(6) Set the CENTER FREQ. control to its 10.00 position and the VERNIER knob to its full cw position.

(7) Observe the output waveform and record the output frequency of each channel as the CHANNEL SELECTOR switch is successively placed in each of its 24 positions.

(8) Review the lists tabulated in steps (5) and (7) to see that all frequencies between 368 cps and 108,000 cps are covered.

NOTE

There will normally be an overlap of the frequencies at the end of each band.

(9) Set the CHANNEL SELECTOR switch to its 70 KC position and then adjust the CENTER FREQ. control and the VERNIER knob to produce a center frequency of 70,000 cps as read on the frequency meter.

(10) Measure the output voltage at both the 5 volt and the 50 volt output connectors (located on the rear panel) with either the calibrated osiclloscope or a peak reading a-c voltmeter (Ballantine 305 or equivalent). The voltages shall not be less than 5.0 volts and 50.0 volts respectively.

(II) Set the CHANNEL SELECTOR switch to its 40 KC position and the deviation toggle switch to its 15% position.

(12) Carefully adjust the CENTER FREQ. control and the VERNIER knob so that the output frequency (f_c) is 40,000 cps.

(13) Connect a d-c voltage source of +18 volts to the INPUT MODULATION connector.

(14) Adjust the DEVIATION control so that the output frequency (f_1) is 46,000 cps.

(15) Without touching any of the controls of the VCO-718, reverse the polarity of the 18 volt d-c input voltage at its source and record the output frequency (f_2).

(16) Determine the deviation linearity as follows:

$$f_1 - f_c = \Delta f_1 \quad \text{(nominally 6000 cps)}$$

$$f_c - f_2 = \Delta f_2$$

Subtract the smaller Δf (Δf_1 or Δf_2) from the larger Δf. The difference shall not be greater than 11 cps.

(17) Set the CHANNEL SELECTOR switch to its 10.5 KC position and the deviation toggle switch to its 7.5% position.

(18) Carefully adjust the CENTER FREQ. control and the VERNIER knob so that the output frequency (f_c) is 10,500 cps. (Use the 10-second count on the frequency meter for this test.)

(19) Re-connect the +18 volt d-c voltage so that it has the same polarity as in step (13) above.

(20) Adjust the DEVIATION control so that the output frequency (f_1) is 11,288 cps.

(21) Without touching the controls of the VCO-718 reverse the polarity of the 18 volt d-c voltage at its source and record the output frequency (f_2).

(22) Determine the deviation linearity as described in step (16) above. The difference obtained shall not exceed 0.31 cps.

C. OUTPUT SYMMETRY ADJUSTMENT

The symmetry of the output square-wave signal is adjusted by variable capacitors C24 and C25. These capacitors are set at the factory

and should not require further adjustment in the field. If for some reason, however, they become misaligned they can be readjusted in the following manner:

(I) Remove the VCO-718 from its equipment cabinet and place it on a laboratory test bench.

(2) Connect the power cord to a 115-volt 60-cycle power source and place the power switch in its ON position.

(3) Allow the unit to warm-up for a period of at least 30 minutes.

(4) Place the CHANNEL SELECTOR switch to one of its unnumbered positions between the 70 KC and .40 KC positions, the CENTER FREQ. control to its 6 00 position, and the VERNIER knob to its mid-range position.

(5) Connect one end of a coaxial test lead to the OUTPUT connector on the VCO-718 and the other end to the input connector on a laboratory oscilloscope which has a good high-frequency response. (Techtronix 545 or equivalent.)

(6) Connect one end of a coaxial test lead to the OUT 2 connector on the rear of the VCO-718 and the other end to the input of a frequency counter. (Berkeley 7150B or equivalent.)

(7) Adjust the controls on the oscilloscope until two cycles are displayed on its screen.

(8) Adjust C24 and C25 until the width of both the positive and negative half cycles are equal as measured at the axis crossing. (Readjust the oscilloscope controls as necessary to keep the two cycles displayed on the CRT screen.)

(9) The output frequency of the VCO-718, as displayed on the frequency counter, should be 100 kc. If otherwise, continue to readjust C24 and C25 until the output frequency is 100 KC and the positive and negative half cycles of the output signal is symmetrically equal.

(10) Remove the interconnecting cable and replace the VCO-718 into its equipment cabinet.

III CORRECTIVE MAINTENANCE

A. GENERAL

When the VCO-718 is not operating properly the malfunctioning circuit should be localized so as to more speedily locate the faulty component. Basically, the VCO-718 consists of five circuits:

(1) The input power circuit.

(2) The power supply and voltage regulator circuits.

(3) The high frequency multivibrator circuit.

(4) The constant current source with its associated modulation deviation circuit.

(5) The output cathode follower circuit.

The sympton column of Table V-1 should assist the maintenance personnel in localizing a malfunction to one of these circuits. Reference should be made to the Schematic diagram (Figure VII-1).

WARNING

This equipment employs voltages that are dangerous and may be fatal if contacted by maintenance personnel.

CAUTION

Never replace a fuse with one of higher rating. If a fuse (or any other component) burns out immediately after replacement do not replace it a second time until the cause has been corrected.

B. TROUBLE SHOOTING PROCEDURE

The trouble shooting procedure listed in Table V-1 assumes that the malfunctioning VCO-718 has been removed from its equipment cabinet and placed on a laboratory test bench. The dust covers should be removed and all components given a close visual check. Any obviously faulty component (such as a charred resistor) should not be replaced until the cause of its failure has been determined. Each vacuum tube should be checked for both emission and shorts on a mutual conductance tube tester and then replaced in the same socket from which it was removed. Test equipment required is:

(1) A multimeter (Simpson Model 260 or equivalent).

(2) An oscilloscope (Dumont Model 304 A or equivalent).

(3) A frequency meter (Berkeley Model 7150 B or equivalent).

SYMPTOM	PROBABLE CAUSE	REMEDY
A 1. No output Signal	Loss of primary power or faulty input power circuit.	1. Check primary power source.
A 2. Front panel indicator not lighted.		2. Check input power cable
A 3. Vacuum tube filaments lighted		3. Replace faulty switch fuse F1.
		4. Replace defective xfmr T1.
		5. Repair open circuit in the primary wiring of T1.
B1. No output signal	Failure in the power supply circuit.	1. Replace faulty electron tubes V8 or V9
B2. Front panel indicator and vacuum tube filaments lighted.		2. Replace shorted C5 or C21.
B3. Voltage regulator tubes not lighted.		3. Replace open circuited LI.
B4. No B + or bias voltage		4. Replace faulty T1 if it has an open circuit.
C1. Erratic output signal	High B+ voltage	1. Replace internally shorted V8.
C2. Abnormal output signal level.		2. Replace shorted R4.
C3. Abnormal output signal frequency.		3. Remove short circuit (associated with V8.)

SYMPTOM	PROBABLE CAUSE	REMEDY
C4. Possible erratic indication of the VR tubes. V6 and V10.	Low B+ voltage.	1. Replace weak V8 and V9. 2. Replace defective C5 or C21. 3 Remove partial short circuit or faulty component in the B+ circuit.
D1. No output signal. D2. Normal +250 volt and -85 volt potentials. D3. No square-wave signal at V2, V3, V4, or V5 for any setting of the CHANNEL SELECTOR switch.	Faulty frequency generating circuit.	1. Repair/replace the faulty CHANNEL SELECTOR switch S3 or its associated wiring. 2. Replace faulty resistor(s) R11 through R28, R34 through R41, or capacitor C15. 3. Remove short circuit; repair open circuit.
E1. Signal missing or distorted on one (or some) channels. E2. Normal 250 volt and -85 volt potentials.	Faulty CHANNEL SELECTOR switch or tuning capacitor(s).	1. Repair/replace faulty switch S3. 2. Replace faulty capacitor(s) C12-a through -t, or C-13-a through -t.
F1. Signal distorted or frequency shifted on all channels. F2. Normal +250 volt and -85 volt potentials.	A component in the frequency generating circuit is either intermittantly bad or has changed value.	1. Replace faulty resistor(s) R11 through R28, R34 through R41 or capacitor(s) C8 through C15. 2. Remove intermittant open circuit or short circuit in the wiring.
G1. Output signal either cannot be deviated or is erroneously deviated with static or dynamic modulation applied.	Faulty modulation circuit or constant current circuit.	1. Replace faulty resistor(s) R23 through R28, switch S2, or MODULATION INPUT jack.

SYMPTOM	PROBABLE CAUSE	REMEDY
G2. Normal +250 volt and -85 volt potentials.		2. Remove short circuit; repair open circuit.
H1. Output signal missing or distorted on all channels.	Faulty output cathode follower circuit.	1. Replace faulty resistor(s) R29 through R33, or capacitor(s) C16 or C17.
H2. Normal signal at pin 8 of V2B.		2. Repair/replace faulty output connector(s).
		3. Remove short circuit; repair open circuit.

PART VI

COMPONENTS LIST

Important

Include the Instrument Model Number, and the Serial Number on the instrument in any correspondence regarding this instrument. Your help in this matter will enable us to answer your questions or fill your order with the least possible delay.

PART VI

COMPONENTS LIST

CAPACITORS

Reference Designation	Value	Manufacturer and Type No.
C1	40ufd, 450V	Aerovox PRS
C2	Not used	
C3	Same as C1	
C4	Same as C1	
C5	Same as C1	
C6	330uuf, 500V	Elmenco DM-15
C8	15 uuf, 500V	Elmenco DM-15
C11	100uuf, 500V	Elmenco DM-15
C12a	14,000uuf, 500V	Elmenco DM-30
C12b	10,000uuf, 500V	Elmenco DM-30
C12c	7,200uuf, 500V	Elmenco DM-30
C12d	5,600uuf, 500V	Elmenco DM-30
C12e	4,300uuf, 500V	Elmenco DM-30
C12f	3,000uuf, 500V	Elmenco DM-19
C12g	2,400uuf, 500V	Elmenco DM-19
C12h	1,800uuf, 500V	Elmenco DM-19
C12i	1,300uuf, 500V	Elmenco DM-19
C12k	1,000uuf, 500V	Elmenco DM-19

CAPACITORS

Reference Designation	Value	Manufacturer and Type No.
C12l	720uuf, 500V	Elmenco DM-15
C12m	510uuf, 500V	Elmenco DM-15 .1/2
C12n	360uuf, 500V	Elmenco DM-15 .3
C12o	210uuf, 500V	Elmenco DM-15 .05
C12p	130uuf, 500V	Elmenco DM-15 .05
C12r	84uuf, 500V	Elmenco DM-15 .05
C12s	51uuf, 500V	Elmenco DM-15 .05
C12t	24uuf, 500V	Elmenco DM-15 .05
C13 a-t	Same as C12 a-t respectively	
C14	Same as C11	
C15	Same as C8	
C16	0.25uf, 400V	Cornell-Dubilier ST4P25
C17	Same as C16	ST4D22 .1
C18	Same as C16	ST4D30 1.
C19	0.1uf, 400V	Aerovox P123ZP
C20	0.1ufd, 400V	Cornell-Dubilier ST4P1
C21	Same as C1	ST4P1
C22	Same as C1	
C23	Same as C20	
C24	3-25uuf, Variable	Cambridge Thermionic CS6-50
C25	Same as C24	

FUSE

Reference Designation	Value	Manufacturer and Type No.
F1	1 Amp., 125V	Little Fuse, 3AG

INDICATOR

Reference Designation	Value	Manufacturer and Type No.
I1	Pilot Lamp	General Electric No. 47

INDUCTOR

Reference Designation	Value	Manufacturer and Type No.
L1	7 henry, 50 ma	Stancor C1707

RESISTORS

Reference Designation	Value	Manufacturer and Type No.
R1	1 meg, ±5%, 1W	Allen Bradley - GB1055
R2	Same as R1	
R4	475K, ±1%, 1/2W	Epsco 54300566
R5	470 ohms, ±5%, 1/2W	Allen Bradley EB4715
R6	Same as R5	
R7	Same as R5	
R9	180 ohms, ±5%, 1W	Allen Bradley GB1815
R10	6.2K, ±5%, 2W	Allen Bradley HB6225
R11	30K, ±0.1%, 1W	Epsco R30POKFFS
R12	100 ohms, ±5%, 1/2W	Allen Bradley EB1015

RESISTORS

Reference Designation	Value	Manufacturer and Type No.
R13	100K, ±0.5%, 1/2W	Epsco R100POKEES
R14	200K, ±0.1%, 1/2W	Epsco R200POKEEP
R15	3.9K, ±5%, 1/2W	Allen Bradley EB3925
R16	10K, ±1%, 5W	Sage SS5W
R17	Same as R16	
R18	Same as R15	
R19	Same as R13	
R20	Same as R14	
R21	Same as R12	
R22	Same as R11	
R23	49.9K, ±1%, 1/2W	Epsco 54300468
R24	Variable: 50K	Helipot, Model A
R25	150K, ±1%, 1/2W	Epsco R150POKFEX
R26	Same as R5	
R27	Same as R5	
R28	Same as R25	
R29	Same as R12	
R30	18K, ±5%, 2W	Allen Bradley HB1835
R31	2.4K, ±5%, 2W	Allen Bradley HB2425
R32	1 meg, ±5%, 2W	Allen Bradley HB1055

RESISTORS

Reference Designation	Value	Manufacturer and Type No.
R33	Same as R32	
R34	Variable: 5000 ohms, 2W	Allen Bradley JU5011
R35	Same as R24	
R36	150K, ±1%, 1/2W	Epsco R150POKFEX 7.6
R37	Same as R36	
R38	Same as R5	
R40	12K, ±1%, 5W	Sage SS5W
R41	87K, ±1%, 1/2W	Epsco R87POKFEX 6.16
R42	120K, ±5%, 1/2W	Allen Bradley EB1245 .24
R43	470K, ±5%, 1/2W	Allen Bradley EB4745 .24
R44	47 ohms, ±5%, 1/2W	Allen Bradley EB4705 .24
R45	Same as R44	
R47	1K, ±1%, 1/2W	Epsco 54300301
R48	1 meg, ±1%, 1W	Epsco 54301601 4
R49	20K, ±5%, 1/2W	Allen Bradley EB2035 .24
R50	40K, ±5%, 10W	Ohmite, Brown Devil 2.49

SWITCHES

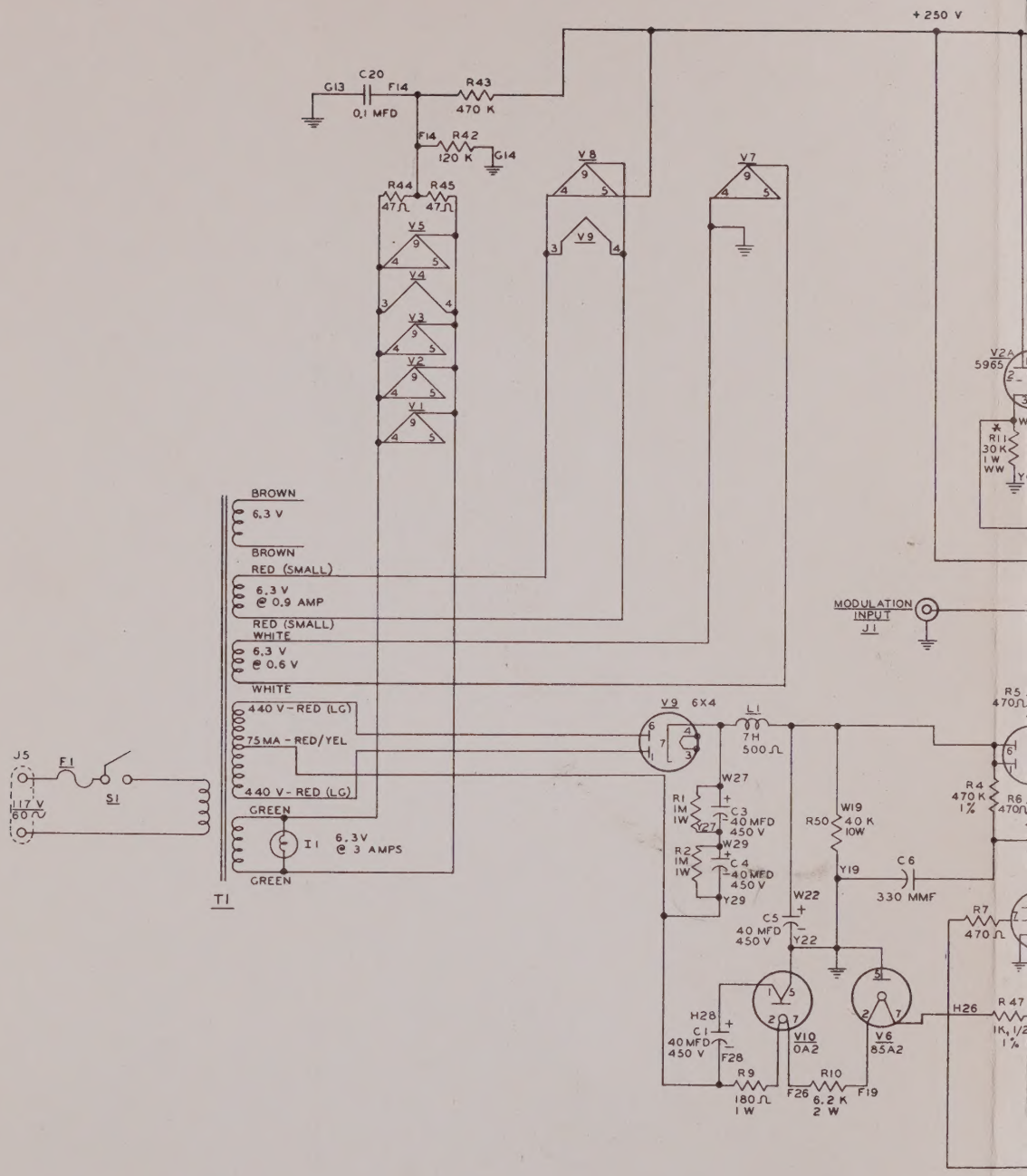
Reference Designation	Value	Manufacturer and Type No.
S1	SPST, Toggle	Arrow H & H
S2	Same as S1	
S3	2 deck, 24 position Rotary, Shorting	Tech Labs, A-1S24-2

TRANSFORMER

Reference Designation	Value	Manufacturer and Type No.
T1	Power	Triad, R-70A 34.00

VACUUM TUBES

Reference Designation	Value	Manufacturer and Type No.
V1	5965	5
V2	Same as V1	
V3	Same as V1	
V4	6AL5	2.75
V5	Same as V1	
V6	85A2/5651	4.30
V7	Same as V1	
V8	6350	5.85
V9	6X4	2.46
V10	OA2	4.40



NOTES:

UNLESS OTHERWISE SPECIFIED

1. ALL RESISTORS ARE 1/2W, 5%

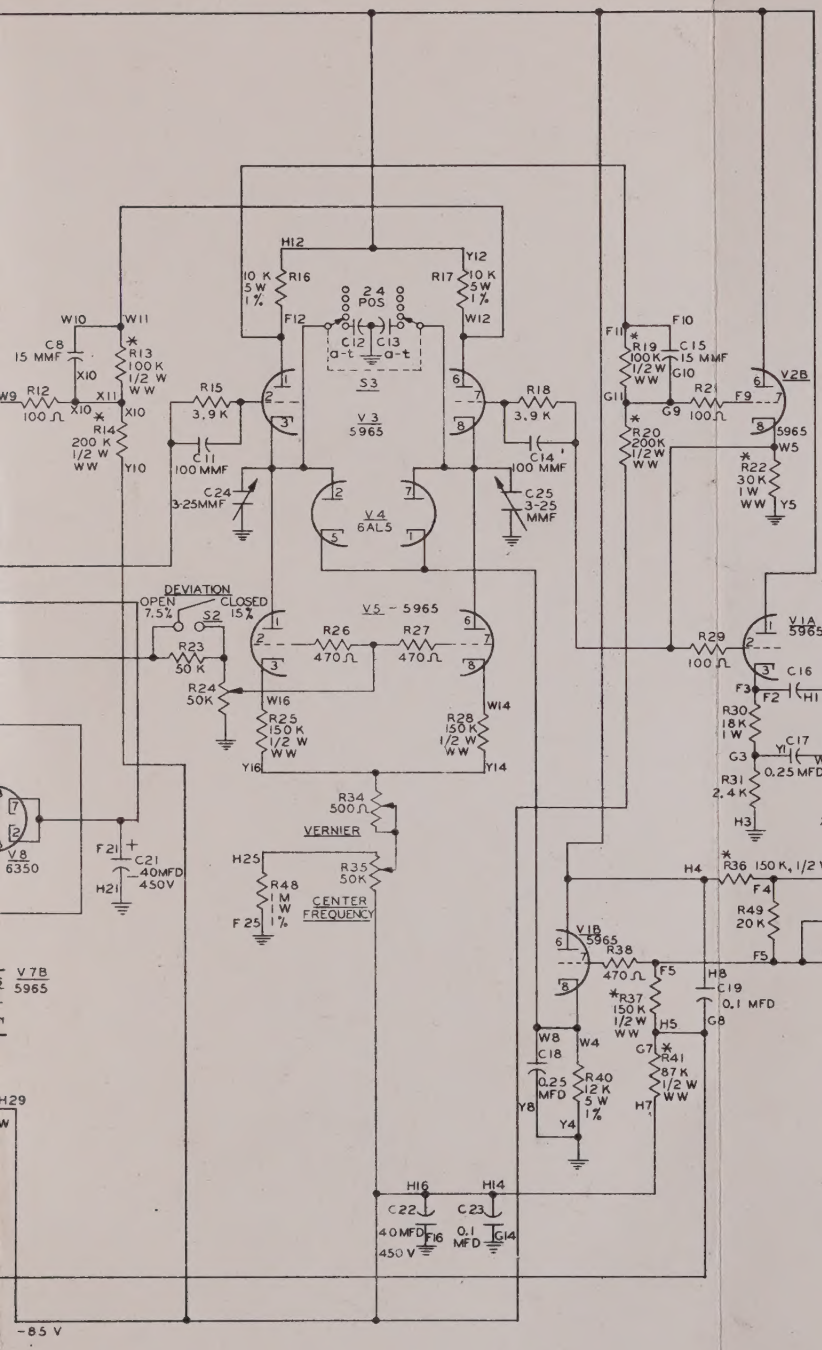


TABLE I			
SWITCH POSITION	CHANNEL (KC/SEC)	C12 & C13 MMF	CHANNEL CAP DESIG
1	.400	14000	a
2	.560	10000	b
3	.730	7200	c
4	.960	5600	d
5	1.300	4300	e
6	1.700	3000	f
7	2.300	2400	g
8	3.000	1800	h
9	3.900	1300	i
10	5.400	1000	k
11	7.350	720	l
12	10.500	510	m
13	14.500	320	n
14	22.000	210	o
15	30.000	130	p
16	40.000	84	Y
17	52.500	51	s
18	70.000	24	t
19-24	100.000	0	-

Figure VII-1 VCO-718 Schematic